

Betpakdalite-NaNa

Crystal Data: Monoclinic. *Point Group:* $2/m$. As striated, doubly terminated, prismatic to bladed crystals, flattened on {001} and elongated along [010], to ~0.4 mm. *Twinning:* Ubiquitous multiple penetration twins result in a prismatic aspect, elongated and striated parallel to [010], with wedge-shaped terminations; penetration twinning forms intersecting blades with X-shaped cross-sections.

Physical Properties: *Cleavage:* {001}, perfect. *Tenacity:* Brittle. *Fracture:* Splintery. Hardness = ~3 D(meas.) = 2.87(3) D(calc.) = 2.877

Optical Properties: Transparent. *Color:* Yellow. *Streak:* Colorless to very pale yellow. *Luster:* Vitreous to subadamantine.

Optical Class: Biaxial (+). $\alpha = 1.768(5)$ $\beta = 1.785(5)$ $\gamma(\text{calc.}) = 1.850$ $2V(\text{meas.}) = 60(5)^\circ$
Pleochroism: None. *Dispersion:* Moderate, $r < v$. *Orientation:* $Y = b$, $X \wedge a = 60^\circ$ in obtuse β .

Cell Data: *Space Group:* $C2/m$. $a = 19.2370(12)$ $b = 11.0945(7)$ $c = 15.1459(9)$ $\beta = 130.342(1)^\circ$ $Z=2$

X-ray Powder Pattern: Chuquicamata mine, Antofagasta, Chile.

8.930 (100), 7.389 (33), 9.640 (30), 11.586 (27), 2.862 (27), 3.697 (25), 3.168 (25)

Chemistry:	(1)
Na ₂ O	5.45
K ₂ O	1.49
CaO	0.12
CuO	0.19
Fe ₂ O ₃	11.15
Al ₂ O ₃	0.01
P ₂ O ₅	1.02
As ₂ O ₅	7.84
MoO ₃	53.94
<u>H₂O</u>	<u>[18.78]</u>
Total	99.99

(1) Chuquicamata mine, Antofagasta, Chile; normalized electron microprobe analysis supplemented by CHN, H₂O calculated from stoichiometry; corresponding to $[(\text{Na}_{2.86}\text{K}_{0.67})_{\Sigma=3.53}(\text{H}_2\text{O})_{14.47}(\text{Na}_{0.90}\text{Ca}_{0.05}\text{Cu}^{2+}_{0.05})_{\Sigma=1.00}(\text{H}_2\text{O})_6][\text{Mo}_8(\text{As}_{1.46}\text{P}_{0.31})_{\Sigma=1.77}\text{Fe}^{3+}_{2.98}\text{O}_{33.42}(\text{OH})_{3.58}]$.

Mineral Group: Betpakdalite supergroup, betpakdalite group.

Occurrence: From the upper oxidation zone of a porphyry copper deposit.

Association: Jarosite, iron oxides and oxyhydroxides (e.g., goethite and akaganéite), scorodite, topaz, leightonite.

Distribution: At the Chuquicamata mine, Antofagasta, Chile.

Name: For the Bet-Pak-Dal Desert, Kazakhstan. Two suffixes correspond to the dominant cations in the two different types of non-framework cation sites.

Type Material: Natural History Museum of Los Angeles County, Los Angeles, California, USA (63570 and 63571) and Museum Victoria, Melbourne, Australia (M51648).

References: (1) Kampf, A.R. and S.J. Mills (2011) Betpakdalite-NaNa, IMA 2011-078. CNMNC Newsletter No. 11, Mineral. Mag., 75, 2892-2893. (2) Kampf, A.R., S.J. Mills, M.S. Rumsey, M. Dini, W.D. Birch, J. Spratt, J.J. Pluth, I.M. Steele, R.A. Jenkins, and W.W. Pinch (2012) The heteropolymolybdate family: structural relations, nomenclature scheme and new species. Mineral. Mag., 76(5), 1175-1207.